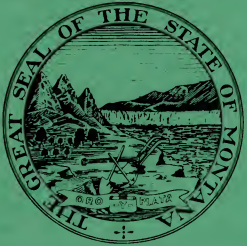
AQUATIC WEED TRAINING MANUAL



STATE OF MONTANA
DEPARTMENT OF AGRICULTURE
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PREFACE

This manual was prepared as a study guide for commercial applicators engaged in control of aquatic weeds. It gives information concerning aquatic herbicide application, control of ditchbank weeds, calculations for herbicide application, and important aquatic weeds found in Montana. It can be used to study for the Aquatic Weed Control examination and as a general reference for identification of aquatic weeds.

To simplify information, trade named products and equipment have been mentioned. No endorsement is intended, nor is criticism implied of similar products or equipment which are not mentioned.

We wish to acknowledge the help of the following: the USDI, Water Power and Resources Services, and personnel of the Environmental Management Division, Montana Department of Agriculture, in preparing this manual.

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CHAPTER I

AQUATIC WEED CONTROL

The problem of controlling aquatic weeds has become important due to increased use of irrigation systems for agricultural purposes and farm ponds for recreational purposes. Many aquatic plants are considered pests due to their relative abundance or the use of the water in which they are found. They can clog irrigation ditches and farm ponds and reduce the value of lakes for recreational purposes.

Aquatic weeds can cause serious problems in irrigation canals due to clogging. They reduce water flow, thus limiting water to important agricultural crops. Water backed up in these ditches also increases water loss because of seepage and evaporation.

Aquatic weeds can be a nuisance in a lake or pond. Most aquatic vegetation in a lake is of little value for fish production. Water weeds utilize nutrients in the water that would otherwise go into production of desirable microscopic plants (phytoplankton), which serve as the fish food base. Weeds interfere with fishing and they may cause fish kills when certain algae decompose during extended periods of cloudy weather. The decomposition of dense weed beds can also lead to winterkill of fish during the ice cover period (depletion of oxygen supply).

Aquatic vegetation may emit offensive odors and give water a bad taste. Some blue-green algae produce poisonous substances which can kill fish, birds and livestock. Many aquatic weeds offer a favorable environment for mosquito production.

Aquatic weeds are common in fertile lakes and ponds. Drainage from barnyards, septic tanks and heavily fertilized farmlands contribute to the fertility of the water when it drains into a lake.

Shallow water is conducive to weed growth because of high sunlight penetration.

New developments have advanced to the stage where most undesirable aquatic weeds can be temporarily controlled. However, there is no method known that will control aquatic weeds permanently. Control techniques used to reduce aquatic vegetation include: mechanical control, cultural methods, control by fertilization, use of inert dyes, biological control and chemical control.

A. CULTURAL CONTROL MEASURES

Any design and spacing in the construction of checks, weirs, turnouts, bridges or other structures along canals can minimize interference with the operation of equipment for mechanical or chemical control of aquatic weeds. If banks are leveled and smooth, hard-to-reach places are eliminated. Lining the canal with concrete or asphalt will help reduce the establishment of aquatic weeds. A uniform canal gradient, with an absence of high or low spots in the bottom, will permit thorough draining of the canal for drying. Deep canals with steep gradients and rapid water flow provide less favorable conditions for growth of submersed rooted plants.

When lakes or drains are constructed, certain precautions can be taken to help prevent the growth of aquatic vegetation. The lake should be located in a site which does not have pollution drainage and where it will not receive excessive run off from fertile farmland. When the lake is constructed, extensive shallow areas (depths less than 3 feet) should be avoided. The shoreline edges should be deepened to three feet or more at the time of construction which will help prevent the growth of

marginal vegetation

One of the most effective control measures is often also one of the most impractical. Draining a ditch or pond and allowing it to dry out will kill a number of different types of aquatic weeds. In irrigation canals it may not be practical to interrupt the water flow for more than a few days when water is not critically needed for crop irrigation. Unfortunately, often the most critical time for control of weeds is when irrigation water is most needed.

B. MECHANICAL CONTROL METHODS

Most aquatic weeds can be controlled when they first appear by hand pulling, cutting, raking or dragging. Such hand methods can be used when the plants are found in small patches. If the plants spread and become extensive, hand removal is not practical.

Aquatic weeds such as cattails, arrowhead and water lily can be removed by pulling when they first start growing. Algae and coontail can be removed by raking. Motor powered underwater weed cutters are available and can be used for the control of aquatic vegetation such as water lilies. These mowers cut the plants 3 to 4 feet below the water surface. There is also a submarine weed cutting saw that is hand operated and works in the same manner to cut the weeds as the motor cutter. When the weeds are cut in this fashion, they must be cut frequently throughout the growing season.

Unfortunately, mechanical control methods usually fragment the weeds often leading to their spread. Most aquatic weed species can reproduce from these fragmented pieces of vegetation.

C. USE OF FERTILIZERS

Fertilization with organic nutrients may be a convenient and inexpensive method for control of aquatic weeds in ponds and small lakes. Fertilization stimulates a dense bloom of microscopic algae which will shade out rooted submersed vegetation. If the fertilization is not done correctly however, the weed problem may become more severe. Fertilization is more effective in deep water than in shallow water. This method of control is not as effective in cooler water of the northern states so its use in Montana is limited.

D. USE OF INERT DYES

This method of control works on the same principle as the use of fertilizers. A dark dye is added to water to shade the bottom of the pond, thus limiting light for growth of submersed aquatic weeds. A dye that is chemically inactive must be used. This method is usually too expensive to be useful in most situations.

E. BIOLOGICAL CONTROL

Several species of fish are herbivorous and aquatic vegetation is their principal diet. Tilapia, a species of fish from tropical regions, feeds primarily on algae. This fish has been used experimentally but it cannot live when water temperatures drop below 50^{o}F., therefore, its use is not practical in Montana.

The grass carp of white amur (Ctenopharyngodon idella) has also been used experimentally for controlling aquatic vegetation and has been recommended experimentally in Montana. Because the environmental hazards of this fish are not fully known, only a

few states permit its use so far. Researchers are now working on a sterile variety of this fish so it will not reproduce and crowd out game fish.

Several insects have been brought into the United States to control aquatic weeds. An *Agasicles* beetle and a stemborer from South America are currently providing excellent control of alligatorweed in areas where this weed is a problem. Alligatorweed does not grow in Montana.

Another important aspect of biological control concerns competitive displacement. Several years ago irrigation personnel in central Nebraska noticed a strange aquatic plant growing on the wetted perimeter of an irrigation canal. It was identified as needle spikerush. It looks like a grass and only grows to a height of 3 inches. It does not restrict the flow of water in the canal and it produces some kind of substance that inhibits the growth of other plants, thus displacing weed species with a beneficial plant. Research is continuing on this plant to determine what factors influence its growth and how best to use it for effective weed control.

F. CHEMICAL CONTROL

Chemicals used in aquatic weed control are classified as herbicides. These herbicides often give more effective, longer lasting and less expensive control than do mechanical or hand methods. While some aquatic herbicides are not toxic to fish at concentrations required to kill weeds, some can be toxic to fish and man and should be used with caution. It is important to handle all aquatic herbicides according to specific label directions and special precautions. Most aquatic herbicides will not injure

crops irrigated with treated water. Label directions and recommendations should be carefully followed when using treated water for irrigation purposes.

Important considerations when choosing a herbicide and rate include the type of weed you want to control, what the treated water will be used for, amount of vegetation to be controlled, water temperature, and site conditions. Local environmental conditions, including climate, water temperature, site conditions and water uses, will affect the performance and persistence of aquatic herbicides. Several herbicides carry water use restrictions limiting swimming, fishing or drinking or return to rivers and lakes for a period of time after application. If water temperatures are too cold (usually less that 50°F.), the weeds may not be adequately controlled by some aquatic herbicides, such as diquat dibromide. Generally speaking, the best time for control is early in the season when young plants are most susceptible and will require less chemical because there is less vegetation to be controlled and there is better contact of the herbicide on target vegetation. It is important to remember that aquatic weeds will continue to grow throughout the growing season and usually several herbicide applications are needed.

Formulations

Aquatic herbicides are available in liquid or granular formulations. The liquid formulations are expressed in pounds of active ingredient per gallon of liquid. Granular formulations are expressed as percent of the active chemical material. See Appendix B, page 29, for a listing of aquatic herbicides by common name, chemical name, active ingredient, trade name and

manufacturer.

Most aquatic herbicides are formulated to be mixed with a water carrier and sprayed. Some perform best as aquatic herbicides when applied to static or flowing water so they disperse evenly and contact the underwater surface of weeds. The types of sprayable or liquid formulations available are: water-soluble powders or crystals that form true solutions in water, wettable powders that can be suspended in water and then applied, water-soluble liquid concentrates that form true solutions in water, emulsifiable liquid concentrates that form ordinary "oil-in-water" emulsions (called invert emulsions) when mixed with water and oil in the spray tank or when applied through special mixing nozzles.

Some aquatic herbicides are used as dry granules of various sizes. The kinds of granular formulations available are: granulated pure chemicals, such as crystalline copper sulfate, granules or larger-size pellets of clay and other materials impregnated with active ingredient, and slow-release granules or pellets designed to release the active ingredient in small amounts over an extended period of time in the water.

Treatment Area

There are four zones of a body of water that may be treated. These include the water surface, the total water volume, the bottom 1 to 3 foot layer of water and the bottom soil surface.

When the surface area of a body of water is to be treated, only 1/3 to 1/2 of the surface area should be treated at a time. This helps protect fish from a possible shortage of oxygen and helps them to escape from treated to untreated water. It usually takes 10 days to 2 weeks to allow oxygen levels to recover before

the remaining area can be treated. Follow the label directions for frequency of application. Surface acreage of a rectangular body of water equals length in feet times width in feet divided by 43,560 (square feet in one acre). The area of a circular shaped body of water can be figured by multiplying 3.1416 times the radius in feet squared and dividing by 43,560. Label directions will indicate how much chemical to apply per acre of water surface.

If a whole body of water is to be treated, from the surface to the bottom, volume must be calculated. Again, if fish are in the area, you will only want to treat 1/3 to 1/2 of the total water volume at a time. The concentration of most chemicals needed to kill aquatic plants is very small, usually stated in parts per million (ppm). This means if you need 2 ppm of a chemical to kill a particular weed, you would add 2 parts of the chemical active ingredient to 1 million parts of the water in the area to be treated.

To calculate the acre feet of a body of water to be treated, multiply surface acres by the average depth in feet. An acre-foot of water weighs 2.7 million pounds. If you dissolve 2.7 pounds of any material in 1 acre foot of water, there will be a concentration of 1 ppm by weight (ppmw). To determine the pounds of material needed to obtain a desired ppm concentration, multiply 2.7 times ppm wanted times acre-feet.

When treating a canal or channel, you are treating the total volume. In this case you must calculate the cubic feet per second of flow to determine the amount of chemical to be used. Do this by multiplying the average width in feet times the depth

in feet times the average velocity in feet per second.

Treating the deepest 1 to 3 feet of water is especially useful in deep lakes where it is impractical to treat the entire volume of water. Such treatments are made by attaching several flexible hoses at 3 to 5 foot intervals on a rigid boom. Each hose may or may not be equipped with some type of nozzle at the end. They may be weighted to reach the depth desired. The length of the hose and the speed of the boat carrying the application equipment also affect the depth of application. Successful bottom treatments apply the herbicide as a blanket in the lower 1 to 3 feet of water.

Direct herbicide applications may also be made to the bottom soil of a drained pond, lake or canal.

All calculations needed for determining herbicide applications are found in Appendix A, page 26, at the back of the manual.

Application

How an herbicide is applied depends upon the type of weed to be controlled and if the water is static or flowing. Floating or emersed weeds can be controlled by direct foliage applications by aircraft, with ground equipment or from a boat, using various types of booms or spray guns. Submersed weeds may be treated by applying either a spray or granule to the water surface or beneath the water surface. In this case, control of the weeds depends on good dispersion of the chemical in the water.

In static waters where there is little or no inflow or outflow, weeds may grow to about the 9 to 12 foot depths. They will grow in deeper water if the water is very clear. There is some

water movement due to wind and other factors. In large impoundments of water, weed control may be poor due to excessive water movement caused by thermal currents or wind. To improve weed control in these cases, use granulars whenever possible, select herbicides that are absorbed rapidly by the weeds, apply herbicides during periods of minimum wind and use bottom treatments whenever possible. Unfortunately, few aquatic herbicides are absorbed. 2,4-D is translocated through foliage and roots and dichlobenil is absorbed primarily through roots.

Aquatic weeds in flowing water are most difficult to control. Because the water is moving from one location to another, the possible hazards of herbicide use are greater. Floating and emersed weeds require the same treatment techniques as those in static water. Effective control of submersed weeds and algae can only be achieved when enough herbicide is applied continuously at a given spot to maintain the needed concentration and contact time.

Correct application of herbicides to aquatic situations involves equipment calibration and calculation of accurate application volumes to target areas. Environmental problems can result from incorrect application rates and application to sites not listed on the label.

CHAPTER II

TYPES OF AQUATIC VEGETATION

There are four general types of aquatic weeds: 1) algae, 2) floating plants, 3) submersed plants, and 4) emersed plants. Since no one herbicide will control all types, it is very important that the weed be identified before application of the herbicide. Help in identification of aquatic weeds can be obtained by sending a sample of the weed to the Montana Department of Agriculture. The plant specimens mailed for identification should be kept moist in thin plastic wrapping.

A. ALGAE

Algae are small, primitive plants which do not have true leaves or flowers and reproduce by means of minute spores. They can be found floating or attached to submerged surfaces in most lakes, ponds and streams. In many waters, particularly in hot weather, these plants multiply rapidly.

Plankton Algae

Excessive growth of microscopic plankton algae, often referred to as a "water bloom" may cause the water to appear soupy green or brown. Common examples of "water bloom" include blue-green algae such as *Microcystis* and *Anabaena*. Plankton algae can be controlled by treating only the upper two feet of water.

Filamentous Algae

Filamentous algae, commonly known as pond scum, consists of growths of long, stringy hairlike strands. Some of the green and brown scums may be slimy or cottony in appearance. Common examples are: *Cladolphora*---cotton mat type; *Spirogyra*

---slimy and green: Hydrodictyon---water net; and Pithophora ---horsehair type.

Chara

Advanced forms of algae such as Chara (see Appendix C - Figure 1) and Nitella grow from the lake or canal bottom with stems and branches and feel gritty due to calcareous deposits on the stems and flowering parts. Chara has a musky odor and is usually found in hard water. Common names of chara are muskgrass and stonewart. Chara and Nitella are often mistaken for underwater weeds such as coontail or milfoil. These plants are sometimes difficult to kill, even when the proper herbicide is used.

Control of Algae

Copper sulfate (bluestone, blue vitrol) is the best and cheapest chemical for the control of most types of algae. In hard water, at or above 150 ppm bicarbonate alkalinity, copper sulfate when dissolved in impounded water unites with carbonates to form an insoluble precipitate and is not available for the control of algae. One effective method of applying copper sulfate in impounded waters is in a solution and spraying it from a boat or the shoreline. Copper sulfate crystals can be placed in a burlap bag and dragged behind a boat. Crystalline copper sulfate is available in crystals the size of rock salt, fine crystals, flakes or powder. The smaller the crystal, the easier it is to dissolve in water. A commercial grade of copper sulfate should be used in algae treatments. Be sure any product you use is a registered pesticide. Good results have also been obtained

when the powdered form of copper sulfate is applied directly to the lake surface.

Copper sulfate is most effective when the water temperature is 60^{O}F. or above. After the algae plants absorb the copper, their color fades from green to grayish white, indicating that the plants are in the process of dying.

B. FLOATING PLANTS

Floating plants are those that are not attached to anything and freely float on the surface of the water.

Water Pennywort (*Hydrocotyle* spp.)

Water Pennywort often grows along the shoreline. It has mature leaves that are round with broad lobes and are about the size of a half dollar. The stalks extend from a horizontal root buried in shallow water. This plant is common throughout the U.S. but seldom reaches nuisance levels.

Duckweed (*Lemna* spp.)

Duckweed and watermeal (*Wolffia* spp.) are floating plants which often form a green blanket on the water surface. Duckweed has tiny leaves (fronds) with rootlets that hang down in the water. Watermeal appears as minute green grains floating on the water and is the smallest of all the flowering plants.

Both of these plants may be found growing together and frequently their growth is so abundant that a layer of plants one to two inches thick may occur on the water surface. The wind and currents will concentrate duckweed and watermeal in certain portions of a lake, canal or drain. Because of this drifting and subsequent layering, these plants are very

difficult to control.

Control of Floating Plants

All of these plants can be controlled by use of the proper herbicide. Many of these plants can reproduce by fragmentation so several treatments may be required for effective control. An even distribution of chemicals assures effective control.

C. SUBMERGENT PLANTS

Submerged aquatic plants are usually, but not always, rooted to the bottom. Their stems and leaves may fill the water to the surface. These plants are commonly called moss, sea weed, bass weed, or water grass. They include many different species of pondweed, coontail, milfoil, waterweed, naiad, water stargrass, horned pondweed, and water buttercup. Some of these plants have floating leaves. Submersed plants have three distinct types of leaf attachments; whorled, opposite, and alternate. Whorled leaf attachments are those that have more than two leaves attached at the same point on the main stem. Opposite leaf attachments are those that have only two leaves attached to the same point on the main stem. Alternate leaf attachments are those that have one leaf attached singly at different heights on the stem. The leaves are in a staggered arrangement and they are never opposite of each other.

NOTE: Illustrations of a number of the species may be found in Appendix C, beginning on page 30.

Pondweed (Potamogeton spp.)

Some important pondweed species in Montana include Sago

pondweed (*P. pectinatus*), clasping leaf pondweed (*P. richardsonii*), small pondweed (*P. pusillus*), curly leaf pondweed (*P. crispus*), large leaf pondweed (*P. amplifolius*), American pondweed (*P. nodosus*), floating leaf pondweed (*P. natans*), and leafy pondweed (*P. foliosus* - figure 5).

Sago pondweed is a bush plant with narrow thread-like leaves alternately arranged on the stem. Nutlets are arranged like beads spaced on a string and emerging from the water. It is found throughout the U.S. in highly variable forms based on local conditions. Treatment prior to vegetative maturity is important for effective long term control. This plant can be a valuable food source in waterfowl areas.

Small pondweed (figure 2) has numerous lateral branches on a slender stem. Narrow ribbon-like leaves are attached alternately on the branches. Leaves are tapered to the point of attachment on the stem and the nutlets are arranged on a spike in a loose pattern. This plant can be a nuisance species in ponds, lakes and irrigation ditches. They often grow relatively deep in the water and are best treated with a granular herbicide. In flowing water, xylene or acrolein are an effective control.

Curly leaf pondweed has thin, membraneous leaves with clearly visible veins and minute teeth visible along the entire margin of the leaf. It commonly grows early in the spring and dies back during mid-summer. The fruits are borne in a spike above the water and the leaves are alternately arranged on the stem. The early growth of this plant often inhibits other weed growth. Control should be early in the

season. Regrowth in the same season once control has been achieved is rare. Often, no later control is needed because the plant dies out in mid-season.

Large leaf pondweed has a large, thick stem with waxy, recurved, oblong, submersed leaves which appear to taper. The floating leaves are ovate and the plant is rarely branched. It has a solid, tightly packed spike or nutlets at the tip of the plant. Often the tough stems and leaves remain standing and intact even after death, especially in hard waters. This plant is very resistant to chemical control so treatments may need to be repeated during the growing season.

Clasping leaf pondweed (figure 3) is similar to large leaf pondweed except that the upper stem is commonly branched. The leaves are wide and wavy with a broad base that appears to extend three-quarters of the way around the stem. The leaves are arranged alternately on the stem. The plants often appear brown due to mineral deposits on the leaves since these plants are common in hard water throughout the Northern U.S. This weed is also difficult to control with most herbicides.

American pondweed (figure 4) has floating leaves that are oval with the base tapered to a distinct petiole. Submersed leaves are oval to lanceolate and tapered to a long petiole. The leaves are sparsely arranged alternately on the stem. Chemical control causes loss of the leaves which will result in death of the entire plant stem and root system. Control should take place before seed heads appear.

Floating leaf pondweed has floating leaves that tend to be slightly heart-shaped at the base. Submersed leaves are either long and narrow or absent. Chemical control should take place before seed heads appear.

Waterstar grass (Heteranthera dubia)

Waterstar grass (figure 6) has stems and leaves that are long, flexible, and grass-like. The leaves are flaccid with a visible midrib. The flower is small, yellow and star shaped. It is found throughout the U.S. generally submersed in shallow, still water. There are several chemicals registered to control this weed.

Water Buttercup (Ranunculus spp.)

The water buttercup has a submersed stem that is erect in the water. It has tufts of thread-like leaves alternating along the stem. Conspicuous yellow or white flowers emerge from the water from June through September. It can be confused with chara. There are various species found throughout the U.S. Good control is often achieved in one application, especially if applied before flowering occurs.

Naiad (Najas spp.)

There are three species of naiad found commonly throughout the United States, including Montana. These are southern naiad (Najas guadalupensis), common naiad (N. flexilis), and brittle naiad (N. minor).

Southern naiad plants are very leafy, with the leaves wider at the base and arranged oppositely on the stem. A tiny seed is concealed at the axis of the leaf and the leaf margins have visible spines.

The common naiad (figure 2) has leaves that are tapered to a fine point with minute spines on the margin. It is very similar to southern naiad and both species are common and widespread with considerable overlap in range. The plants often grow in thick clumps or beds so good coverage and dispersion of chemicals is required to achieve control.

The brittle naiad has long, pointed leaves with distinct spines. The leaves are arranged oppositely on the stem. The entire plant is brittle and breaks easily. It is found throughout the U.S. but rarely reaching a nuisance concentration.

Horned Pondweed (*Zannechellia palustris*)

Unlike the other pondweeds discussed, this species has all leaves that are arranged oppositely on the stem. A fragile stem rises from a horizontal root. The leaves are long and narrow with flattish seeds attached to the stem at the base of the leaves. This species and its varieties are found throughout the U.S. in fresh or brackish water. It isn't usually a nuisance species but can get tangled on the ends of fish lines. It is usually controlled with a single chemical treatment.

Milfoil (*Myriophyllum* spp.)

This is a hollow stemmed plant with whorled leaves at intervals along the entire length of the plant. The leaves are finely dissected to the midrib and feather-like in appearance. The plants are submerged except for a stalk of tiny flowers which may extend above the water surface. It often occurs in extensive patches crowding out other aquatic plants. Treatment should occur when plants are established

but before flowering occurs. Two common species in Montana are northern water milfoil (M. exalbescens - figure 8) and broadleaf water milfoil (M. hippurioides - figure 9).

Coontail (Ceratophyllum demersum)

Coontail (figure 10) is a plant found throughout the U.S. commonly in hard water areas. It is a submersed plant without roots. The leaves are dark green in color and arranged in whorls on the stem. Coontail can be distinguished from milfoil by the forking of the leaves rather than the feather-like divisions. Spacing between the whorls is highly variable, consequently, the plants may be bushy or extremely long and sparse. Treatment should take place when plants have accumulated in shallow waters. Floating plants that are buoyed up by algae growth should be treated with a liquid spray.

American Elodea (Elodea canadensis)

Elodea (figure 11) is a submersed weed with broad oval leaves, usually four in number, arranged in whorls around the stem. Whorls are compact near the growth tip and gradually increase their spacing further down the stem. They are usually found in hard water and are best treated when the plants are matured. Fragmented portions can develop into new plants so good chemical coverage is necessary.

Bladderwort (Utricularia spp.)

This is a free floating plant without any visible roots. It has finely divided leaves that are scattered along the stem with numerous bladder-like structures on the leaves. These bladders act as traps to capture small aquatic inver-

tebrates. This genus is common throughout the U.S. in various forms. Since it is not rooted it may reinfest treated areas. Control is difficult because the plant is not rooted and floating plants may reinfest a treated area.

Control of Submergent Plants

Submersed plants and algae may be controlled with either spray or granular herbicide formulations. Herbicide sprays may be applied to the surface in shallow water or under the surface by injection through a hose or boom. The herbicide is dispersed throughout the water by diffusion, thermal currents or wave action. Granular herbicides perform best when distributed evenly over the water surface. The advantages of using a granular are: treatment is confined to the bottom where the submersed weeds are, slow release provides a long contact time with weeds, herbicide concentrates are held at a low level and they make it possible to use chemicals that would be toxic to fish in other formulations. Fewer chemicals are available to control submersed weeds in flowing water. Copper sulfate will control algae and Sago and leafy pondweeds. Xylene and acrolein control most other weeds. All aquatic herbicides should only be used according to label directions. Xylene and acrolein can be extremely toxic to fish; copper sulfate is generally not toxic when used at recommended rates in western waters.

Appendix B is a list of many chemicals registered for aquatic weed control. For identification of aquatic weeds, send a sample wrapped in damp paper towels and plastic wrap to the Montana Department of Agriculture/EMD-TSB, Agriculture/

Livestock Building, Helena, Montana, 59601. Phone number is (406) 449-2944.

D. EMERGENT PLANTS

Plants which grow above the water in shallow areas of ponds, lakes, irrigation ditches and drains, and rivers are referred to as emergent. These plants are generally rigid and are not dependent on water for support. Many are not truly aquatic but can survive in saturated soils or submersed for a considerable period of time in water. These plants may be annual or perennial types. Some of the emersed plants include cattails, lotus, water lily, creeping primrose, smartweed, bulrush, waterwillow, willow, and buttonbush.

Common Cattail (*Typha latifolia*)

Cattails (figure 12) have long, slender, grass-like stalks up to 10 feet in height. They inhabit wet lowlands and are found in water to 4 feet deep. To assure good chemical control, spray the chemical until it runs off the plant. Plants should be sprayed before the seed head is formed to prevent re-seeding.

Smartweed (*Polygonum* spp.)

Smartweed or knotweed is an erect rooted plant with alternate, oblong leaves. The stem is distinctly jointed. It has small, tightly clustered flowers that are generally pink or rose colored. The plant may be emergent in shallow water or completely submersed with only flowers visible above the water. This plant can live on mud flats and moist soils so care should be taken when treating these areas.

There are two species that are found in Montana, swamp smartweed (P. coccineum - figure 13) and water smartweed (P. amphibium - figure 14).

Hardstem Bulrush (Scirpus acutus)

The hardstem bulrush (figure 15) is a perennial herb that has a hollow, jointed stem. It has a modified leaf (bract) that is erect with conspicuous red-spotted scales on the mature fruit. These scales are often fringed with bristles of a variable length. The plant usually matures in July to August. It is found in swamps, along shores and in shallow water throughout most of the U.S. except in the southeast.

Common Arrowhead (Sagittaria latifolia)

Arrowhead (figure 16) is a perennial herb that grows either in marshes or submersed. It has a variable leaf type. Depending on where it is growing, the leaf blades vary from oval to linear and are usually deeply lobed at the base. The plant has showy, tiny white flowers that grow in whorled clusters. It is found in water and wet places along lakes, ponds, rivers, bays and swamps. It is common throughout the U.S. except in the southern parts of Texas, New Mexico, Arizona and California.

Watercress (Nasturtium officinale)

Watercress (figure 17) is an aquatic or marsh herb that reproduces by seed and rooted stems. It has pinnate leaves with 3 to 11 leaflets that are round to oblong in shape. The stems are succulent and smooth, either creeping or floating and freely rooting. The flowers are white and the seeds

set any time between April and October. It is found in brooks, rills, and springheads and is often cultivated in cool waters.

Control of Emergent Plants

Since these plants are found out of the water, a contact herbicide, which hits the foliage directly, can be used for control. Use of a wetting agent and foliage application prior to seed set will generally be an effective control. See Appendix B for a list of chemicals registered for aquatic weed control.

CHAPTER III

DITCHBANK WEED CONTROL

Ditchbank weeds are a major problem in irrigation systems. They reduce water flow causing: 1) flooding, 2) seepage, 3) breaks in ditchbanks, 4) increased evaporation and transpiration loss, 5) decreased water delivery to farmland, and 6) decreased water drainage from farmland. They can also obstruct inspection and maintenance operations of irrigation systems and cause silt deposits in irrigation channels.

The term "ditchbank weed" includes any plant of a wet or dry habitat that becomes established along the ditch and either interferes with water flow or presents a problem to adjacent farmland. Perennial weeds, such as Canada thistle and quackgrass; woody species, such as willows or wild roses; and annuals, such as sunflower or Russian thistle can all be classified as ditchbank weeds. Even some misplaced crops can become troublesome on ditchbanks.

Although rank vegetation on ditchbanks is disadvantageous, some vegetation is useful. Soils that are easily eroded or ditchbanks that are used for pasture need soil-binding vegetation. Ditchbank weed control should be considered from many angles so treatment can be suited to particular ditches.

A. MECHANICAL CONTROL

On high-value land and under critical water supply conditions, a lined ditch or underground pipeline may be justified and is a good solution to ditchbank weed control problems.

Mowing is a widely used and practical method for controlling ditchbank weeds. It effectively limits seed production and growth

of such weeds as Canada thistle, wild rose or wild mustard. This method also encourages growth of perennial grasses. Unfortunately, the mower often can't reach all plants on the bank.

Boom-type bottled gas burners can be an effective plant control. The main disadvantages of this method are cost and necessity of frequent retreatments. Mowing followed by burning can give good seasonal control of many annuals and some perennials.

B. CHEMICAL CONTROL

The most important thing to remember when choosing a chemical for weed control on ditchbanks is to READ THE LABEL. Very few chemicals can be used on ditches when water is in them. See Appendix B.

APPENDIX A

CALCULATIONS FOR HERBICIDE APPLICATIONS

Definitions

cfs = cubic feet per second
ppm = parts per million
ppmw = parts per million by weight
ppmv = parts per million by volume
ai = active ingredient
ac-ft = acre-feet
sq.ft. = square feet
cu.ft. = cubic feet

To Channels or Canals

cfs = av. width (ft) x av. depth (ft.) x av. velocity (ft.per sec.)

$$\text{gal. chemicals per cfs} = \frac{\text{ppmv} \times 450 \times \text{minutes applied}}{1{,}000{,}000}$$

$$\text{ppmv} = \frac{\text{gal. chemical per cfs} \times 1{,}000{,}000}{450 \times \text{minutes applied}}$$

$$\text{total gal. chemical required} = \frac{\text{ppmv} \times 450 \times \text{cfs} \times \text{minutes applied}}{1{,}000{,}000}$$

$$\text{ppmw} = \frac{\text{lb. of chemical} \times 1{,}000{,}000}{\text{cfs} \times 3744 \times \text{minutes applied}}$$

$$\text{ppmw} = \frac{\text{gal of formulation} \times \text{lb.ai per gal.} \times 1{,}000{,}000}{\text{cfs} \times 3744 \times \text{minutes applied}}$$

$$\text{gal.formulation per cfs} = \frac{\text{ppmw} \times 3744 \times \text{minutes applied}}{\text{lb. ai per gal.} \times 1{,}000{,}000}$$

$$\text{lb. of chemical per cfs} = \frac{\text{ppmw} \times 3744 \times \text{minutes applied}}{\text{lb. ai per gal.} \times 1{,}000{,}000}$$

To Ponds or Lakes

vol. of pond (cu.ft) = surface area (sq.ft.) x av. depth (ft.)

vol. of pond (ac.ft) = surface area (ac) x av. depth (ft.)

$$\text{vol. of pond (ac.ft)} = \frac{\text{vol. pond (cu.ft.)}}{43{,}560}$$

$$\text{ppmv} = \frac{\text{gal.of 100\% ai}}{\text{vol.(ac.ft)} \times .33}$$

total gal. of chemical required = ac.ft. x ppmv x .33

$$\text{ppmw} = \frac{\text{lb. ai of chemical applied}}{\text{vol. (ac.ft.) x 2.72}}$$

total lb. ai required = ac.ft. x 2.72 x ppmv desired

total gal. of liquid formulation required =

$$\frac{\text{ac.ft. x 2.72 x ppmw desired}}{\text{lb. ai per gal. concentrate}}$$

Units and Conversion Equivalents

1 acre = 43,560 sq. ft.
1 acre foot (ac.ft.) = 43,560 cubic feet = 325,872 gal. = 2,720,000 lb. of water
1 cfs = 450 gallons per minute (gpm)
1 cu.ft. = 7.48 gal. = 62.4 lb. of water
1 gal. = 128 fl. oz. = 8.33 lg. of water
1 ppmv = 1 gal. per million gal. of water
1 ppmw = 8.33 lb. chemical per million gal. of water
1 ppmw = 2.72 lb. chemical per ac.ft. of water
weight per CFS of water = 3744 lbs./minute

$$\text{gal.of liquid formulation required} = \frac{\text{lb. ai required}}{\text{lb. ai per gal. concentrate}}$$

$$\text{lb. of dry formulation required} = \frac{\text{lb. ai required x 100}}{\text{\% ai in formulation by weight}}$$

Use the preceding calculations to try the following problems:

1. You wish to treat an irrigation lateral with xylene to control Sago pondweed. The lateral has a mean width of 10 feet, an average depth of 4 feet, and is flowing at an average of 1.5 feet per second (FPS). Growth of sago is quite heavy so you wish to reach a maximum concentration of 740 ppm in the water, applied over a 30 minute time period. How much xylene do you apply in 30 minutes?

   (CFS) Cubic Feet per Second = 10 x 4 x 1.5 = <u>60</u>

$$\text{Total Gallons of Chemical Required} = \frac{\text{PPMV x 450 x CFS x minutes}}{1{,}000{,}000}$$

$$= \frac{740 \times 450 \times 60 \times 30}{1{,}000{,}000}$$

$$= 599.4$$

   599.4 gallons of Xylene are applied during a 30 minute period.

2. You are treating a 1,000 CFS irrigation canal with acrolein to control a moderate infestation of potamogeton pondweeds and filamentous algae at the rate of 2 gallons per CFS over an 8 hour period. What concentration in ppmv are you getting in the water?

$$\text{PPMV} = \frac{2 \times 1{,}000{,}000}{450 \times 8(60)}$$

$$= \frac{2{,}000{,}000}{216{,}000}$$

$$= 9.26 \text{ ppmv}$$

3. You have a fish pond with a mean length of 200 feet, a mean width of 150 feet and an average depth of 6 feet. It is heavily infested with filamentous algae. You wish to treat with copper sulfate crystal at 25 percent copper ion content by towing cloth bags suspended in the water behind a boat. You wish to treat at the maximum rate of 1 ppm. copper ion in the water. How much copper sulfate crystal do you apply?

$$\text{Volume of Pond in Acre Feet} = \frac{200 \times 150 \times 6}{43{,}560}$$

$$= 4.13$$

$$\text{Total lb. AI required} = 4.13 \times 2.72 \times 1$$

$$= 11.23 \text{ lb. or AI}$$

$$11.23 \times 4 = 44.9 \text{ Total lbs. of 25\% copper sulfate}$$

APPENDIX B

CHEMICALS REGISTERED FOR AQUATIC AND DITCHBANK WEED CONTROL

Common Name	Chemical Name	Trade Name	Weeds Controlled	Comments
acrolein	acrylaldehyde	Magnacide H	aquatic weeds	Restricted use pesticide. Use with extreme caution.
amitrole	3-amino-1,2,4-triazole	Amitrol-T Amizol Cytrol Amitrol-T	cattails, grasses, annual and perennial broadleaf weeds	Drainage ditches only.
copper	copper	Cutrine-Plus Copper sulfate	algae, chara algae, sago & leafy pondweeds	Do not treat more than 1/3 to 1/2 of the lake or pond at one time.
2,4-D	2,4-dichlorophenoxyacetic acid	Aqua-Kleen 1 Vegetrol LV-40 LV OXY-4D 3 Visko Rhap - LV-2D 3 Weedar 64 2	1 - aquatic weeds 2-3 various broadleaf weeds	1 - Lakes and ponds only. 2 - For use on ditchbanks with running water. Do not apply cross channel. 3 - Lakes, ponds and drainage ditches only.
dalapon	2,2-dichloropropionic acid	Dowpon M 4	perennial grasses and cattails	4 - For use on wet ditches.
dichlobenil	2,6-dichlorobenzonitrile	Casaron G-10	submerged aquatic weeds	Consult with Fish & Game prior to use in public waters.
diquat	6,7-dihydrodipyrido (1,2-a: 2',1'-c) pyrazinediium dibromide	Aqua-Cide Aqiatate Water Weed Killer CRC-27 Con-Quest Aqua Kill Con Kill Watrol	algae, pondweed, other aquatic weeds	For use in lakes, ponds, & irrigation channels & drains. See label for irrigation channel restrictions.
simazine	2,chloro-4, 6,bis(ethylamino)-2-triazine	Aquazine	algae, pondweed other aquatic weeds	Apply to ponds only.
xylene	petroleum distillates	Aquatic Weed Killer Cyclosol 31	algae, pondweed, other aquatic weeds	Do not allow treated water in excess of 10 ppm to return to rivers and streams.

APPENDIX C

COMMON AQUATIC WEED SPECIES

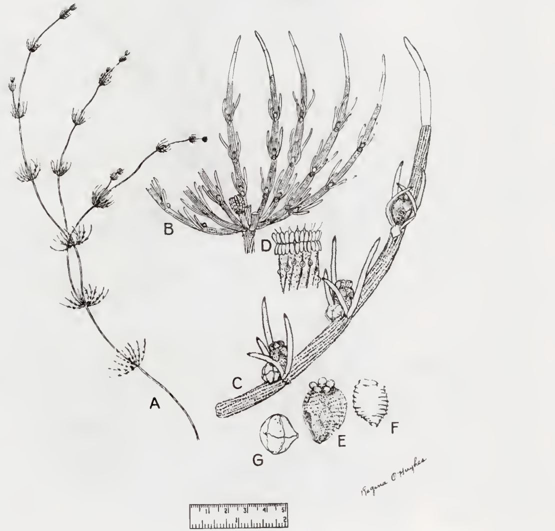

Figure 1. Chara (Chara vulgaris L.) A. habit x 0.5; B. whorl of branchlets x 6; C. branchlet x 12; D. stipulodes x 24; E. oögonium x 20; F. oöspore x 20; G. antheridium x 20.

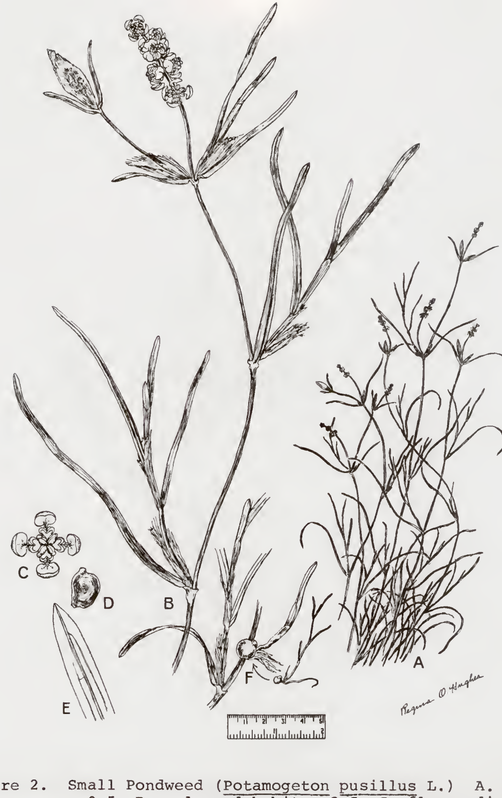

Figure 2. Small Pondweed (Potamogeton pusillus L.) A. Habit x 0.5; B. enlarged habit x 2.5; C. flower diagram x 4; D. achene x 4; E. tip of leaf showing nerves x 7.5; F. winter bud x 2.5.

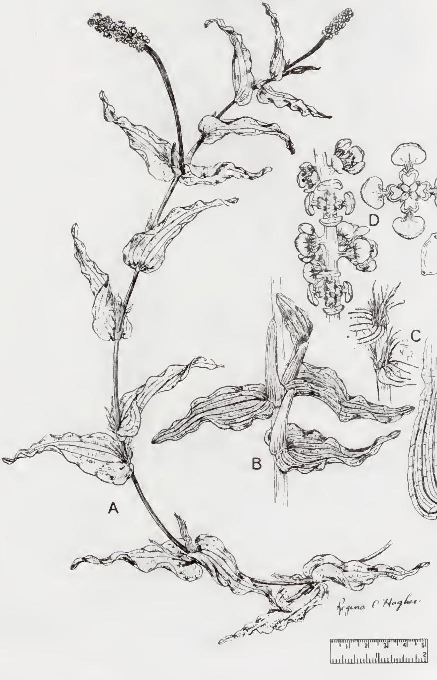

Figure 3. Claspingleaf (Richardson) pondweed (Potamogeton richardsonii (A. Benn.)) A. Habit x 0.4; B. enlarged leaves with young stipules x 1; C. enlarged bases of leaves x 1.5; D. flowers x 2.5; E. achene x 2.5.

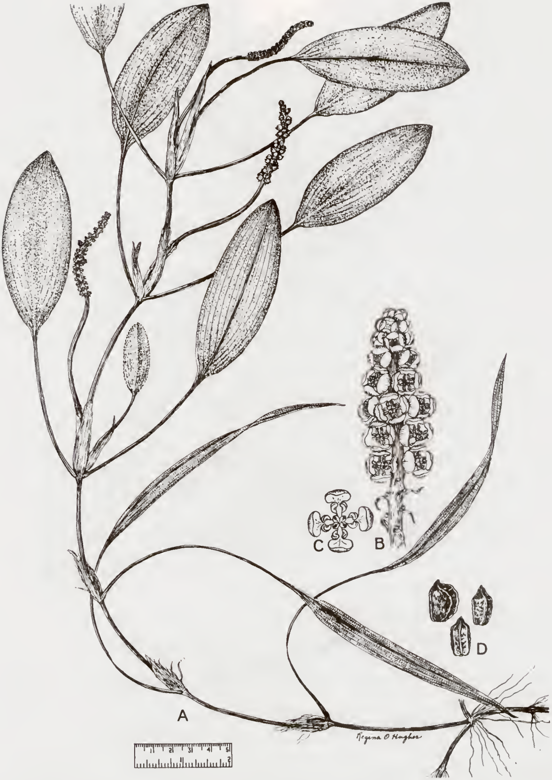

Figure 4. American pondweed (Potamogeton nodosus Poir.)
A. Habit x 0.5; B. flower spike x 3; C. flower diagram showing stamens x 3; D. achenes x 3.

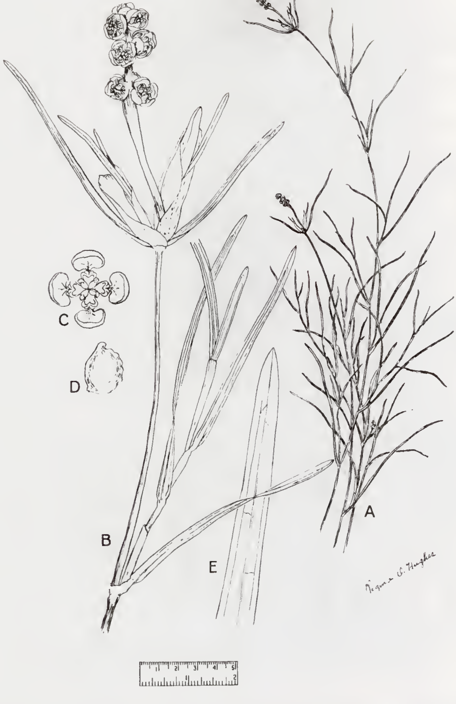

Figure 5. Leafy pondweed (Potamogeton foliosus Raf.) A. Habit x 0.5; B. enlarged habit x 2.5; C. flower diagram x 5; D. achene x 5; E. tip of leaf showing nerves x 7.5.

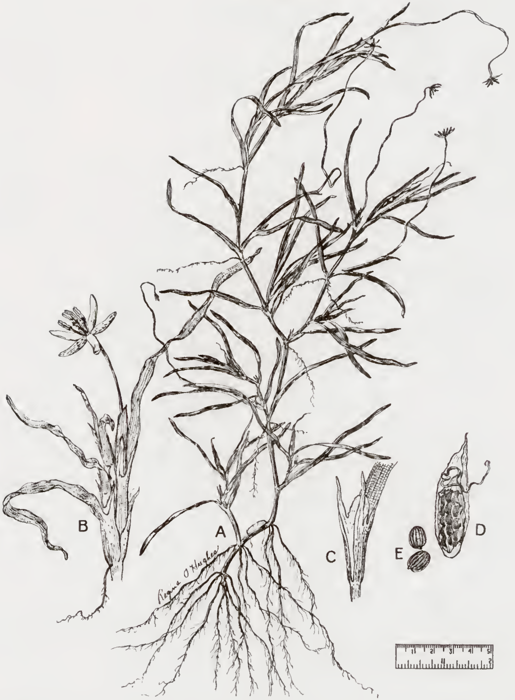

Figure 6. Waterstargrass (Heteranthera dubia (Jacq.) MacM.)
A. Habit x 0.5; B. enlarged habit, showing flower x 1.5; C. sheath at base of leaf, showing stipule-like appendages x 2; D. capsule x 5; E. seeds x 10.

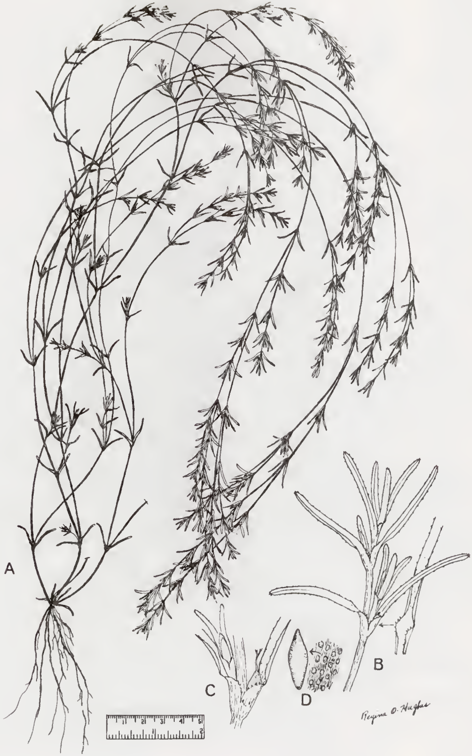

Figure 7. Slender naiad (Najas flexilis (Willd.)) A. Habit in running water x 0.5; B. leaf detail x 2.4; C. flower detail, pistillate flower x 2.5; D. seed x 6, with enlargement showing rows of areolae.

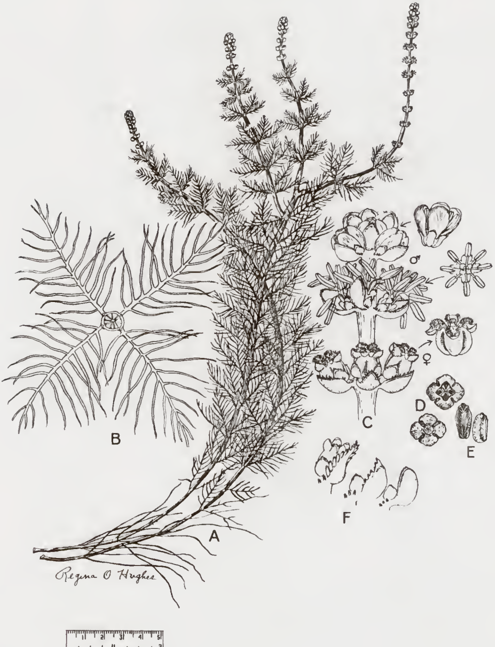

Figure 8. Northern milfoil (<u>Myriophyllum</u> <u>exalbescens</u> Fern)
A. Habit x 0.5; B. whorl of leaves x 1.5: C. flower with spike, male and female flowers x 5; D. shizocarps x 5; E. mericaps x 5; F. bracts x 5.

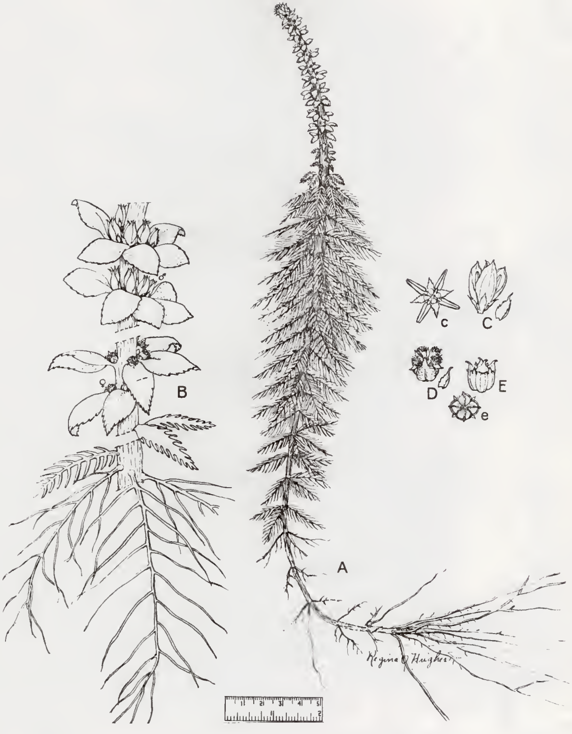

Figure 9 Broadleaf Milfoil (<u>Myriophyllum</u> <u>heterophyllum</u> Michx.) A. Habit x 0.5; B. leaf and flower detail x 2.5; C. staminate flower and bract x 5; C. diagram of staminate flower x 5; D. pistillate flower and bract x 5; E. mature fruits x 5; E. top view of mature fruits.

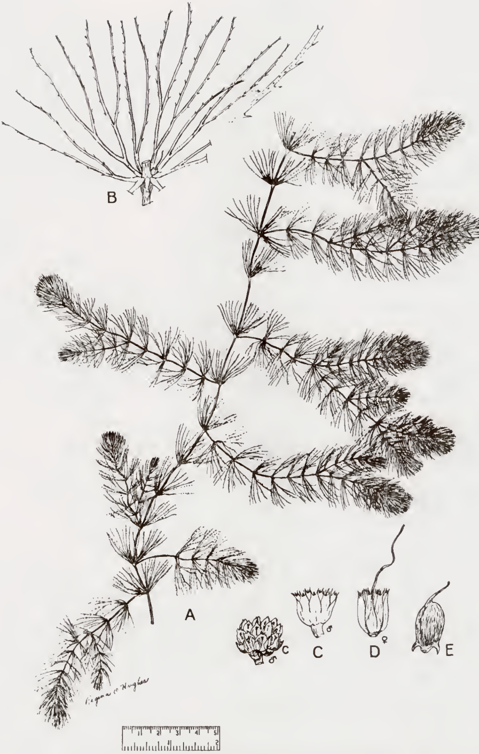

Figure 10. Coontail (Ceratophyllum demersum L.) A. Habit x 0.5; B. leaf detail, showing a pistillate flower x 3; C. staminate flower x 10; C. staminate flower showing developed stamens x 10; D. pistillate flower x 10; E. achene x 2.5.

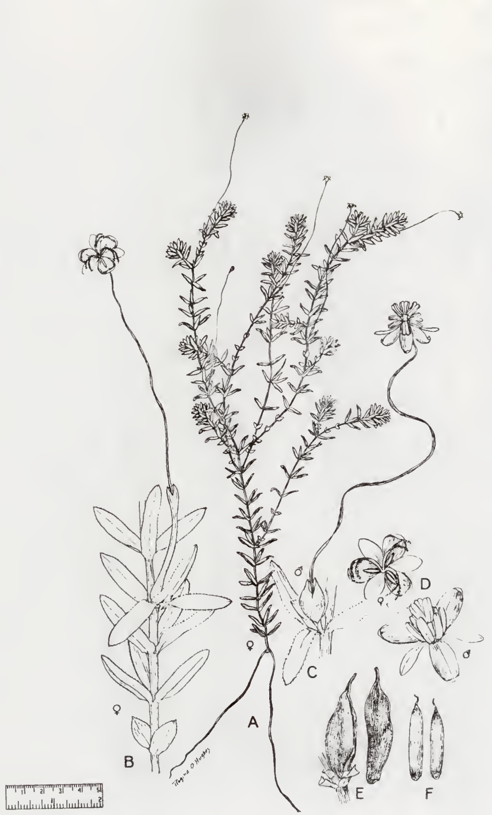

Figure 11. American elodea (Elodea canadensis Michx.) A. Habit pistillate plant x 0.5; B. flower and leaf detail, pistillate plant x 2.5; C. flower and leaf detail, staminate plant, flower fully expanded, sepals and outside anthers fallen x 1.5; D. flowers, female x 4; male before full expansion, all others upright x 2.5; E. capsules x 4; F. seeds x 4.

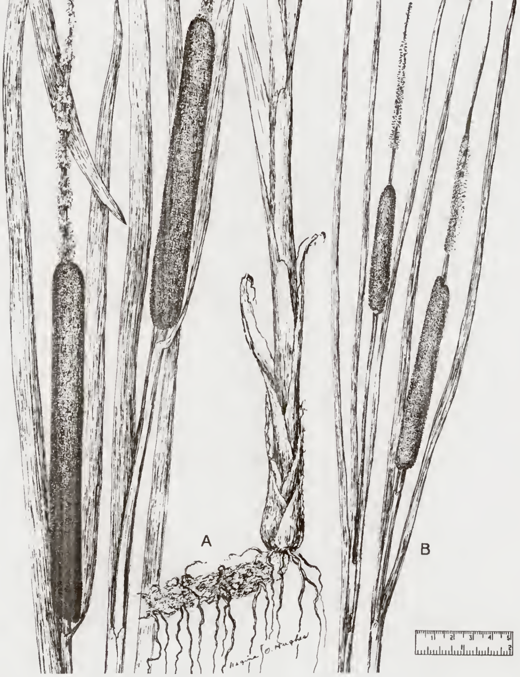

Figure 12. A. Common Cattail (Typha latifolia L.) Habit x 0.5:
B. Narrowleaf Cattail (Typha angustifolia L.)
Habit x 0.5.

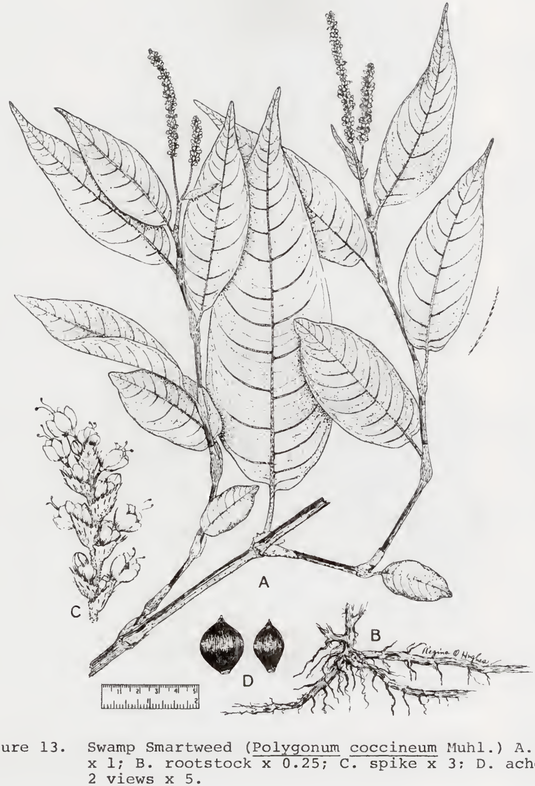

Figure 13. Swamp Smartweed (<u>Polygonum</u> <u>coccineum</u> Muhl.) A. Habit x 1; B. rootstock x 0.25; C. spike x 3; D. achenes, 2 views x 5.

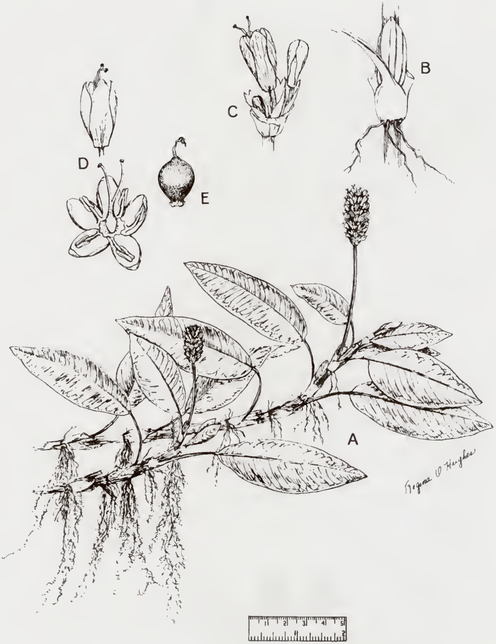

Figure 14. Water Smartweed (Polygonum amphibium L.) A. Habit x 0.5; B. ocrea x 2.5; C. flower cluster, showing sheath and bilobed sheathing bracts x 3; D. flowers x 3; E. achene x 3.

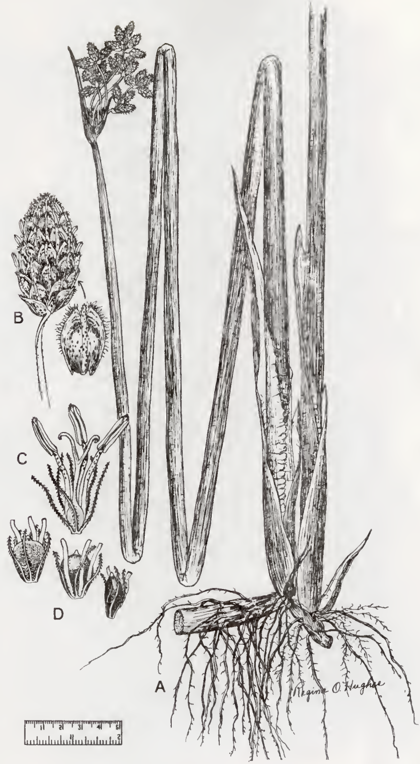

Figure 15. Bulrush (Scirpus acutus Muhl.) A. Habit x 0.5; B. spikelet x 2.5; C. flower x 7.5; D. achenes x 5.

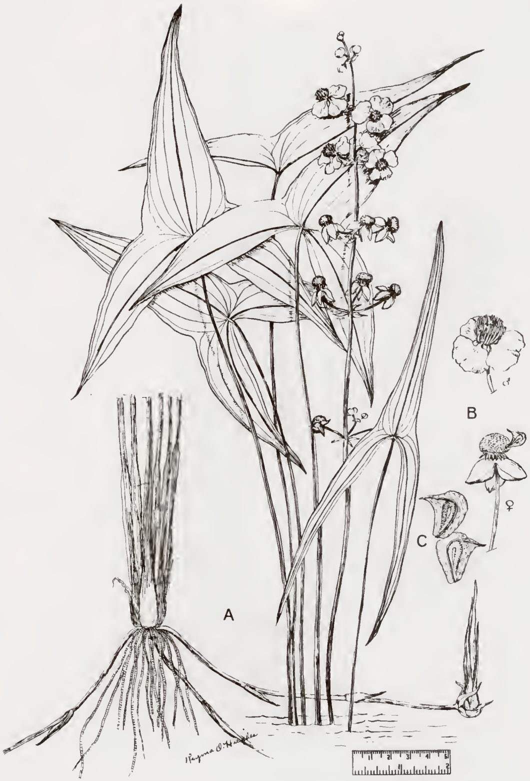

Figure 16. Common Arrowhead (<u>Saggitaria</u> <u>latifolia</u> Willd.)
A. Habit x 0.5; B. flowers x 0.5; C. achenes x 5.

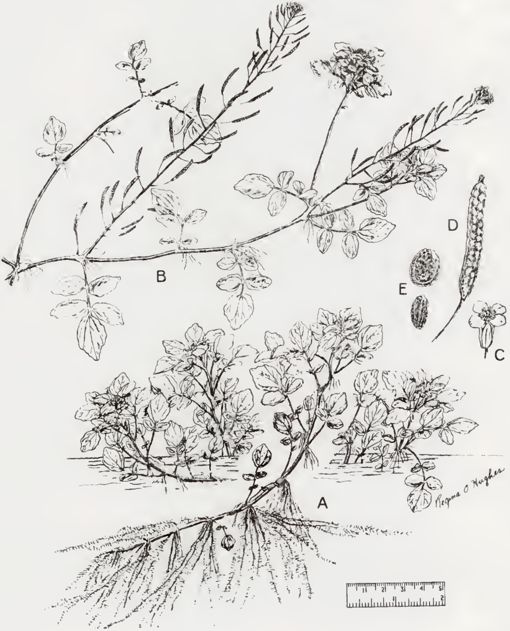

Figure 17. Watercress (Nasturtium officinale R. Br.) A. Habit x 0.5; B. elongated mature plant x 0.5; C. flower x 2; D. silique x 2; E. seeds x 10.

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